The Costs and Benefits of Effluent Management Compliance in the Waikato Region of New Zealand

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Abstract: Dairy farming in the Waikato Region has contributed greatly to the reduction of water quality. Part of this is attributable to the issue of inappropriate disposal of dairy effluent. Regional authority data shows both costs and benefits of complying with effluent management regulations. Private costs result from system and management improvements, while private benefits are largely due to reduced fertiliser requirements. Decreases in the volume of 'non-compliant effluent', resulting from improved compliance, are used as an indicator to illustrate reduced environmental effects. The benefits of becoming compliant outweigh the costs for half the farms analysed. More incentives are required to promote compliance from the other farms although their environmental effects are generally smaller.

Key words: Dairy farming, environment, effluent, compliance, cost, benefit.

1 Introduction

Despite the increased profile of environmental issues the quality of natural waterways continues to decline. This paper looks at the costs and benefits involved with environmental compliance as an incentive to reduce negative environmental effects. The focus is on the effects caused by the dairy farming industry in the Waikato Region of New Zealand and specifically relates to their compliance with effluent irrigation regulations.

The historic increase in global economic activity resulting from population and per-capita income growth, along with the intensification of farming systems, has been matched by a growing deterioration of the natural environment. It is well known in the scientific realm that all agricultural practices have impacts on the environment and, in the past two decades especially, interest from the general public in this area has increased. The negative environmental effects of dairy farming are of particular concern. There are many papers (including Cullen, Hughey & Kerr, 2006; Lodge & Rutherford, n.d.; Tait & Cullen, n.d.; Takatsuka *et al*., 2007; Vant, 2008; Wilcock *et al.,* 1999) that discuss the detrimental environmental impacts of dairy farming and many of these suggest that outcomes to date have understated the negative impact. A recent report from Environment Waikato (2008) on regional soil and water quality is seen as one of the more realistic publications.

Dairy farming damages water (both surface water and groundwater), air, ecosystem biodiversity and human health (Clark *et al.,* 2007; Tait & Cullen, n.d.). Of these, the impacts on water are seen as paramount (Cullen, Hughey & Kerr, 2006; Morriss, 2004). The main effects on water are increased levels of suspended solids, inorganic nutrients and pathogens and a reduction in available oxygen (Dragten, 2006; Vant, 2006). Common causes of these effects are allowing stock access to waterways, the mismanagement of fertiliser and the inappropriate disposal of farm dairy effluent (Cullen, Hughey & Kerr, 2006; Lodge & Rutherford, n.d.). Although it is argued that fertiliser and waterway management are of greater environmental concern, both are outside the scope of this research.

Farm dairy effluent is a collective term that includes cow faeces, urine and yard washwater. It only includes the controllable volume that is deposited in the cowshed and yard. Farm dairy effluent also includes small amounts of udder washwater, milking plant washwater and any milk spillage (Dragten, 2006; Fyfe, 2004; Longhurst, Roberts & O'Connor, 2000; MAF, 1994). “Typical New Zealand dairy farm milking practices lead to a considerable transfer of nutrients from pastures to the cowshed” (Monaghan *et al.,* 2007, p. 186). This transfer of nutrients represents a significant volume of effluent (6-15% of total cow effluent output) that requires disposal (Dragten, 2006; MAF, 1994).

Up until the late 1970’s, it was common practise for Waikato dairy farmers to dispose of untreated farm dairy effluent directly to surface water. As a result of the increased importance of environmental effects, regional authorities have restricted the way that farmers can dispose of effluent. There are now two commonly accepted methods of discharging effluent - treated discharge to surface water and untreated discharge (irrigation) to land. The careful irrigation of effluent to land allows natural soil processes to effectively break it down and results in lower environmental effects than discharging effluent to surface water.

The Resource Management Act 1991 (the RMA) is the main body of environmental legislation in New Zealand. The RMA prohibits contaminant discharges unless authorised by a regional plan or resource consent (Resource Management Act 1991). Under the RMA, farm dairy effluent is a contaminant as it contains a range of characteristics that are likely to affect water. Environment Waikato (EW), acting under the RMA, is the regional authority that governs the use of natural resources in the Waikato Region. It sets rules in the Waikato

Regional Plan regarding the disposal of contaminants. The rules in the regional plan state that no resource consent is required to irrigate farm dairy effluent to land as long as specific conditions are met. These conditions relate directly to reducing the environmental effects of inappropriately discharged effluent. In the literature there is considerable discussion on environmental policy and discussed also, in detail, are the effluent management regulations in the Waikato Region. Some discuss the implications of the regulations while others (for example Cassells & Meister, 2001) are more constructive and discuss dairying in light of the regulations.

The main mechanism to reduce the environmental effects of effluent has been through a tightening of environmental regulations (Cassells & Meister, 2001; Morriss, 2004). Effluent disposal - as more of a point-source discharge - is quite a developed issue. This has resulted in its regulation being quite developed. As effluent management has relatively straightforward regulations, enforcement of non-compliance is a simple policy option. Regulation has been used rather than other, more voluntary, pathways given the capital-intensive nature or costs associated with becoming compliant (Clark *et al.,* 2007).

To this end, EW undertakes compliance monitoring of dairy farms that irrigate effluent to land. A monitoring inspection involves an assessment of the dairy shed, yard, effluent storage facility and irrigator. In monitoring a farm effluent system, the activity is assessed against the rule conditions and a compliance status is given. Compliance can range from Full Compliance, through High Level of Compliance and Partial Compliance, to those that are Significantly Non-Compliant. A Significantly Non-Compliance status will be assigned to farms that have direct discharges to water, major ponding on the land surface, or, in the opinion of the monitoring officer, are likely to have a significantly adverse environmental effect.

There has been reluctance to becoming compliant, both in New Zealand and abroad, and this has been the focus of much investigation (including Davies, Kaine & Lourey, 2007; Winter & May, 2001). Bewsell & Kaine (2006) have gone to the extent of including the impact that farm context has on the adoption of environmental practices. Monaghan *et al.* (2007) identifies key barriers as “cost, complexity, compatibility with the current farm system, and a perceived uncertainty of actual environmental benefits” (p.181).

The attitudes that farmers hold towards the environment are another topic debated in the literature. While some claim that farmers hold a negative view (or even disregard) for the environment, others (including Wunderlich, 1991 cited in Chouinard *at al.,* 2008) state that farmers are inherent stewards of the land. Many farmers consider that farming in itself is maintaining the environment (Ward *et al*., 1990 cited in Curry, 1996). The notion of farmers being environmental stewards should be viewed with scepticism as most of this is based on farmer self-assessments. This scepticism is heightened following the importance of cost-based motivators. As Bewsell & Kaine (2006) have pointed out, regardless of environmental attitudes decisions are based more on a systematic evaluation of context and available options.

Winter & May (2001) divided motivations for environmental compliance into calculated, normative, and social motivators. Although only one of the three motivators (calculated motivations) relates to money, for most farmers it is the most important. Some (including Nowak, 1987 cited in Chouinard *et al.*, 2008) argue that although monetary motivators are commonly superior, the other motivators do provide Private Benefit - and these can sometimes outweigh monetary Private Cost.

The normative and social motivators both push farmers towards compliance whereas the calculated motivators, depending on whether these are costs or benefits, can push farmers away. As monetary costs are paramount for (most) farmers, the easiest way to ensure environmental compliance would be to ensure that the actions are profitable. The result would be ‘pushes’ towards compliance from all three motivators. Further work in this area is needed and, if the findings are positive, could increase the uptake of environmental regulations.

It has been said that those “subject to tighter environmental regulations will incur higher costs than firms subject to weaker, or non-existent, environmental regulations” (Cassells & Meister, 2001, p. 258). This may be accurate in regard to the costs of becoming compliant, however, what is missing is the inclusion of (both monetary and non-monetary) Private and Social Benefits that result from the environmental compliance subsequently achieved.

This study assesses EW’s compliance monitoring data for the farms with the largest environmental effect (those classified as ‘Significantly Non-Compliant’). It assigns a Private Cost and Private and Social Benefit to farms becoming compliant with effluent regulations and allows the calculation of a Cost Effectiveness.

Social recognition is one of the motivators for environmental compliance (Winter & May, 2001) and the reason that society would recognise such actions relates to Social Benefit. The results of environmental compliance benefit society as a whole (including future generations) as an increase in compliance decreases environmental effects. Environmental effect is relative to numerous factors (including soil type, receiving environment, etc) and a calculation of the actual environmental effect is outside the scope of this research. Instead, the volume of ‘non-compliant effluent’ is used as an indicator. The indicator shows the volume of effluent that will become adequately disposed of as a result of the improved compliance and will provide the Social Benefit of reduced environmental effect.

The Private (or Abatement) Cost is the cost a farm faces in becoming compliant. The main Private Cost of improving compliance relates to the price and capital-intensive nature associated with effluent management. Often there are system improvements or a large amount of labour required to bring a system to a compliant level: this relates to the size of the milking herd. In the case of installing a new system, issues of complexity and compatibility with the current system also add to costs.

Improving systems or management practices to become compliant with environmental regulations sometimes offer a Private Benefit. Although this is not the case for all farms or for all regulations, Private Benefit does come about from improved compliance with effluent management regulations. The main Private Benefit is an increase in the amount of effluent being effectively utilised as fertiliser. When effluent is irrigated to land it acts as a fertiliser because it contains high levels of nitrogen and phosphorus. The fertiliser value of the effluent from 100 cows has been estimated to be around $2855/year (M. Bramley, Pers Comm, 10 September 2008). The increase in the quantity of effluent being effectively utilised as fertiliser will vary depending on the scale of the compliance improvements and this affects the amount of savings that any one farm would make. This is the only Private Benefit investigated in this study and the volume of ‘non-compliant effluent’ is used to calculate this.

In removing the Private Benefit from the Private Cost, the Net Private Cost shows the actual cost of improved compliance. The Net Private Cost can be compared with the Social Benefit to show a Cost Effectiveness.

2 Method

EW's effluent irrigation compliance monitoring data was looked at for each Significantly Non-Compliant farm. The analysis assessed the non-compliance in more detail and also looked at the problem behind the non-compliance and the solutions required to fix it.

The 'problem' is the reason for the non-compliance. On a farm there is usually a combination of reasons for the non-compliance, however, there is usually one dominant cause or 'problem'. Problems were seen to be either System Failures or Management Failures and costs were assigned accordingly. A Management Failure results from a human error. This can include a pump not being switched on or the irrigator not being monitored or shifted enough. The solution for a Management Failure requires an increase in the time spent monitoring and managing the effluent system. Increased training of staff will also reduce the chance of a Management Failure. A System Failure occurs when something goes wrong with the system/mechanics and include pump or irrigator breakdown. Solutions for System Failures include increased maintenance or the installation of all or part of a new system. The problems were looked at in more detail and a 'Private Cost' to become compliant (Abatement Cost) was determined. This was based on whether the problem stemmed from a Management Failure or a System Failure and was proportional to herd size.

The total effluent produced on each farm was estimated using a standard volume of 50litres/cow/day. The environmental effect within the Significantly Non-Compliant category can range from a minor spill to a catastrophic event and, because of this, the total volume of effluent produced on a farm is not always a reliable indicator. A survey of EW monitoring staff allowed a scale of non-compliance to be assigned to each farm and this took into account the differing types of non-compliance. This scale showed a proportion of the total effluent that was non-compliant and this volume was used as an indicator of Social Benefit.

The largest Private Benefit is the saving made once the nutrients in the non-compliant effluent become utilised as fertiliser. The fertiliser savings was calculated using $2855/100 cows/year. The Net Private Cost is the Private Cost subtracting the Private Benefit. This is the actual cost to the farmer - although becoming compliant will cost the farmer, this will be subsidised by the benefit the farmer gains from the reduced fertiliser costs.

A Cost Effectiveness was calculated from the cost of a farm becoming compliant (Net Private Cost) and the reduction in non-compliant effluent (Social Benefit). This is a dollar value per cubic metre of effluent. Assuming a linear relationship, for every dollar a farmer spends towards becoming compliant, an *X* volume reduction in non-compliant effluent results. Using Waikato regional figures, the findings were extrapolated to a regional level.

3 Results & Discussion

Environment Waikato data shows there are approximately 4678 dairy farms in the Waikato Region. It showed that 4033 farms irrigate effluent to land and that the number of these farms that were randomly monitored during 2006-2008 was around 422 (10.5%) per season. The focus of this research is only on the 9% of these randomly monitored farms that were Significantly Non-Compliant (Figure 1).

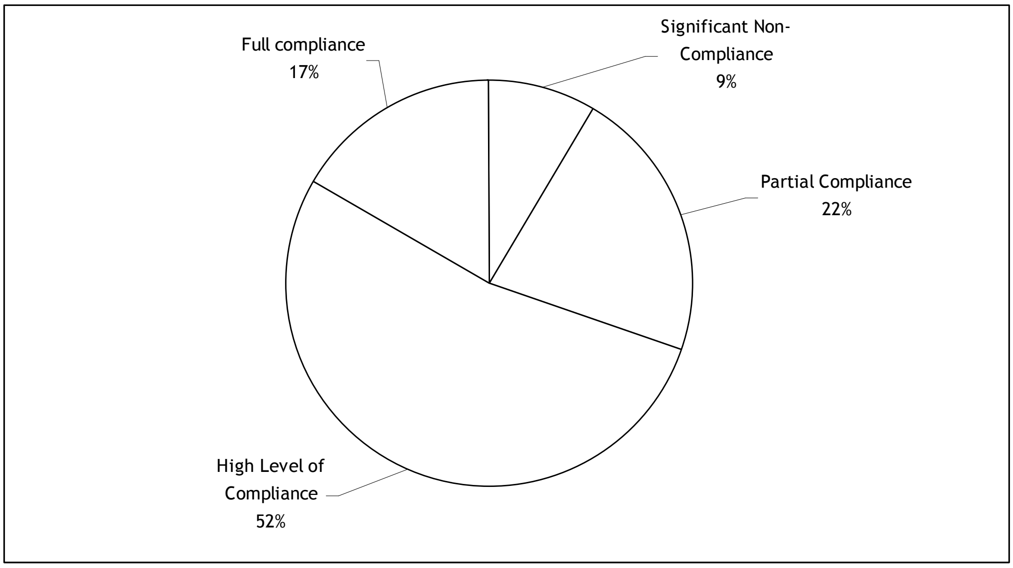

Figure 1: Compliance of the Waikato dairy farms that irrigate effluent to land

For the Significantly Non-Compliant farms, the average herd size is 320 cows (Waikato regional average 316 cows) and the average farm size is 118ha (Waikato regional average 110ha). These figures show that farm and herd size do not appear to effect whether or not a farm is non-compliant. Table 1 summarises the main findings of this study, showing the descriptive statistics of the main characteristic examined.

Table 1: Summary of descriptive statistics

	Min	Lower Quartile	Mean	Standard deviation	Median	Mode	Upper Quartile	Max
Effluent produced (m^3)	2.50	9.05	16.00	10.77	12.20	8.00	18.13	57.50
Social Benefit (m^3)	0.56	2.55	7.71	6.55	5.34	2.56	11.05	29.63
Private Benefit ($)	0.88	3.98	12.06	10.25	8.36	4.00	17.28	46.34
Private Cost ($)	1.46	4.98	10.46	8.54	8.87	1.46	11.98	59.34
Net Private Cost ($)	-28.56	-7.55	-1.61	8.67	-0.57	2.65	3.81	16.80
Cost Efficiency ($/$m^3$)	-1.44	-0.65	-0.21	2.76	-0.24	0.92	0.97	13.81

Without comparison it is not known whether major non-compliance from a small herd is higher or lower than minor non-compliance from a large herd. Figure 2, however, shows that there is a strong correlation between herd size and volume of non-compliant effluent. The amount of non-compliant effluent (Solution Benefit) for major non-compliance from small herds, say under 400 cows, is comparable to minor non-compliance from larger herds. This suggests that minor non-compliance from a large herd is more of an issue than major non-compliance from a small herd.

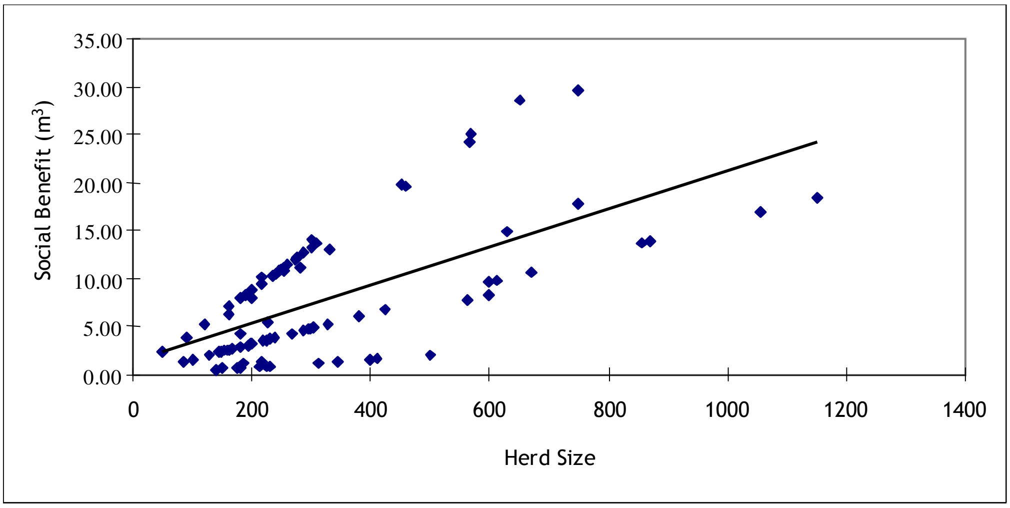

Figure 2: Herd size compared to Social Benefit (reduction in non-compliant effluent)

The actual environmental effect that this would result in was not analysed in this research – hence the notion of an indicator. The typical contaminant composition of effluent together with other variables such as soil type and the sensitivity of the receiving environment could be used to estimate the actual and overall environmental effect of non-compliant effluent.

The Private Cost for the majority (65%) of Significantly Non-Compliant farms is less than $10/farm/day. The Private Cost for a Management Failure is, on average, $3.24/farm/day more expensive than that for a System Failure. The large System Failures, however, are much more expensive than the larger Management Failures and usually require an entirely new system.

In regard to the Private Cost of a Management Failure, it may have been better to look at the opportunity cost of monitoring the effluent system. This is because labour is already being paid for and, although the actual price throughout a year is constant, the worth of each unit is not. For example, one hour spent on the effluent system in summer will be worth much less than one hour spent during a busy time such as calving.

The average Net Private Cost for becoming compliant is -$1.61/farm/day. A negative Net Private Cost means the Private Benefit exceeds the Private Cost. The analysis into Net Private Cost shows that the 50% of farms with a negative Net Private Cost would be better off to change. The other 50% (those with a positive Net Private Cost) would require some other incentive but, for the majority, the incentive needed would be less than $5/farm/day.

Figure 3 shows the Net Private Cost. The red line depicts the level at which the Private Cost is equal to the Private Benefit – at any point along this line, a farmer would be indifferent. All the farms under this line would be better-off if they improved their effluent system to become compliant (Private Benefit is greater than Private Cost). These farmers should improve their system simply because the value of the fertiliser they are currently losing is more than the cost that would be incurred to utilise it (that is, become compliant). It is not known why these farmers have not taken action to improve their system - it may be an information lack or lag regarding the size of potential Private Benefit. All the farms above this line would not be better-off if they improved their effluent system to become compliant (Private Cost is greater than Private Benefit). For these farms there is no monetary incentive to improve compliance.

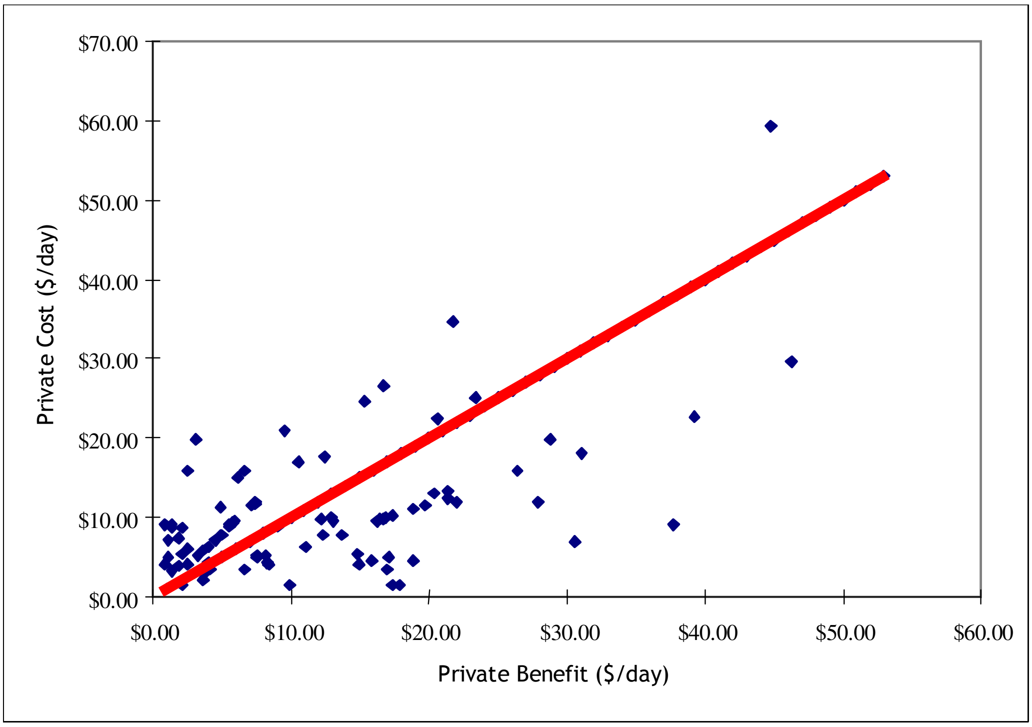

Figure 3: Private Cost compared to Private Benefit

Figure 4 compares the Net Private Cost to herd size and shows that regardless of whether a farm has a negative or positive Net Private Cost, the larger the herd size, the larger the magnitude of the Net Private Cost. Those to benefit from becoming compliant will gain increased benefit, and those not to benefit will lose more, as herd size increases.

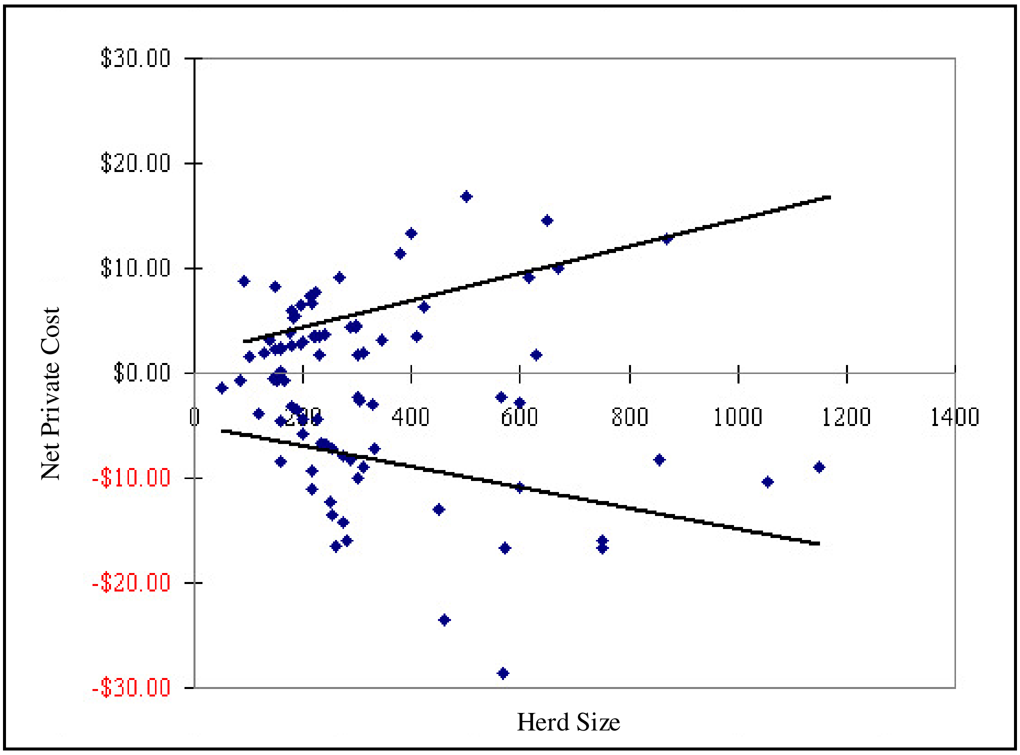

Figure 4: Net Private Cost compared to herd size

Farms with larger herd sizes and a positive Net Private Cost are a major problem because, as we know from Figure 2, non-compliant effluent is proportional to herd size. The negative implication of this is that those with a positive Net Private Cost and a large herd size will not only have a large effect but will also be those least likely to become compliant. This is only an indirect link at this stage.

The trend line in Figure 5 shows that for the typical farm the point at which Private Benefit starts to exceed Private Cost is when the volume of non-compliant effluent (Q) exceeds 5.7m^3. From the trend line, *Private Cost* = 4.5 + 0.77 x *volume of non-compliant effluent*.

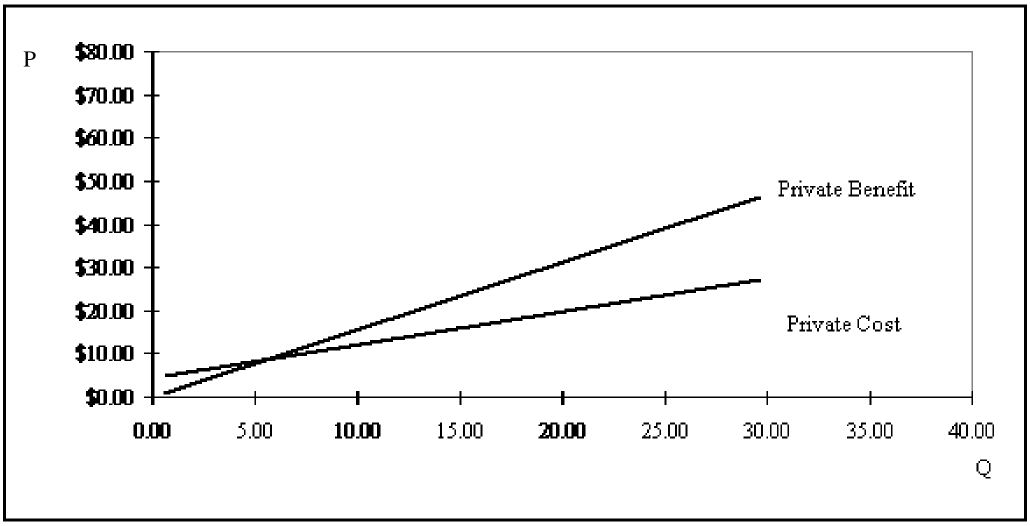

Figure 5: Private Benefit v Private Cost Curve

The average Cost Effectiveness is (-\$1.61 ÷ 7.71m^3) \$-0.21/m^3 reduction in non-compliant effluent. This means that, on average, Net Private Benefit will be \$0.21 for each cubic metre reduction in non-compliant effluent (or, for every \$1 of Net Private Benefit, the result will be a 4.80m^3 reduction in non-compliant effluent). This is misleading, however, as it suggests that every farm would benefit from becoming compliant – when this is not the case. A more accurate approach is to group those with positive Net Private Cost and those with a negative Net Private Cost together or to group the values of the Cost Effectiveness. As explained, 51% of the farms have a negative Net Private Cost (that is, they would benefit from improving compliance). The average Cost Effectiveness for these farms is \$-0.73/m^3. At the extreme, one farm would have a surplus of \$1.44/m^3 from reducing 11.44m^3/day. The average Cost Effectiveness for farms with a positive Net Private Cost is \$2.64/m^3. At one extreme a farm would only need to spend \$0.10/m^3 to reduce 2.56m^3/day, compared to the other extreme where the farmer would need to spend \$13.81/m^3 to reduce 0.6m^3/day.

Figure 6 reduces the concerns previously raised in regard to farms with Net Private Cost and large herd sizes. This is done by showing that the majority of farms with large volumes of non-compliant effluent (large Social Benefit) have a negative Net Private Cost. This is because Private Benefit is directly proportional to the Social Benefit (as both are calculated from the volume of non-compliant effluent). In a common circumstance, as the Social Benefit increases, the Net Private Cost decreases. The implication of this is encouraging and suggests that those with larger volumes of non-compliant effluent (larger effect) should benefit more from becoming compliant.

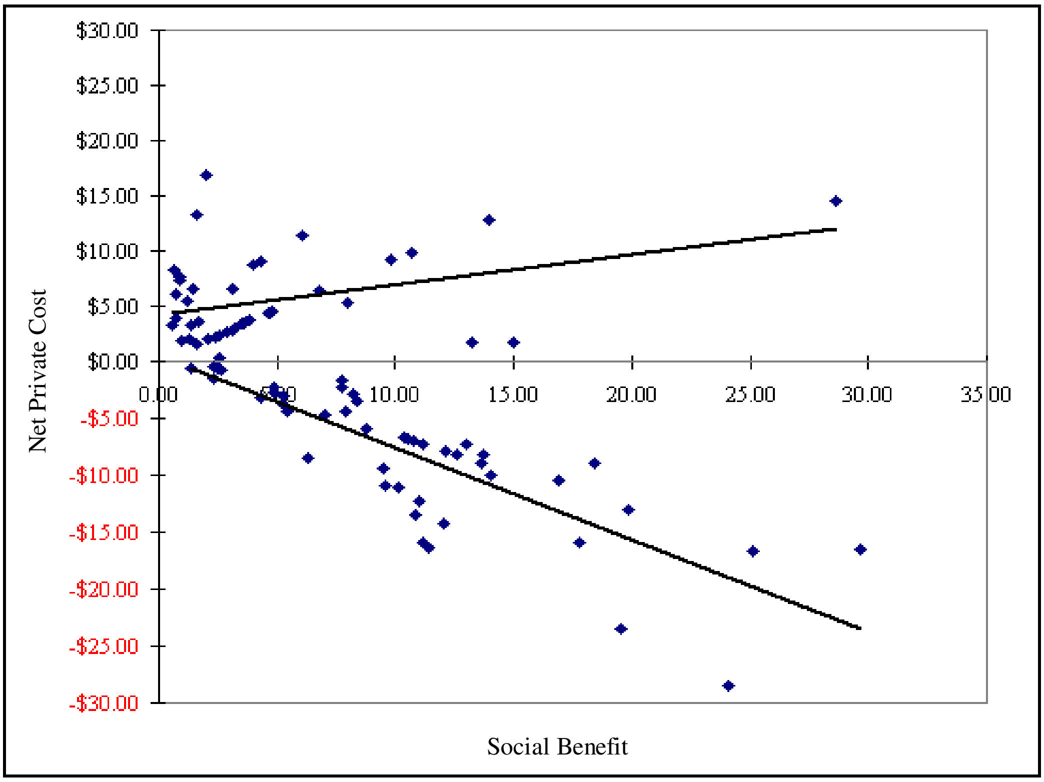

Figure 6: Net Private Cost compared with Social Benefit

Projecting the non-compliance rate onto the 4033 farms in the region shows that at any one time approximately 363 will be Significantly Non-Compliant. Using these figures, a daily surplus of $558 will reduce the volume of non-compliant effluent by 2675m^3. As discussed, the straight projection of the average is misleading. A closer analysis shows that 177 of the Significantly Non-Compliant farms would have a negative cost effectiveness (on average $0.73/m^3), 110 farms would need to pay around $0.92/m^3 and, at the far end of the scale, there would be four farms with a cost effectiveness of $13.81/m^3.

For farms with a negative Net Private Cost, the comparatively large Private Benefit is providing an incentive to become compliant. For those with a positive Net Private Cost, there will need to be some other incentive to promote compliance. In this analysis an assumed goal is a 100% reduction in Significantly Non-Compliant farms.

The research identified the volume of non-compliant effluent as an indicator only and this, although quantified, was not assessed through into monetary terms. Working this into a monetary value would allow a direct comparison between Net Private Cost and Net Social Benefit. This would allow a Cost Benefit Analysis to be performed. Some simple inferences can be made without quantifying the actual Social Benefit. Once such example would be the promotion of a subsidy to promote compliance through reducing Private Costs. This becomes complicated, however, as the subsidy would only be necessary for those with a positive Net Private Cost.

To ensure a move toward compliance, an incentive would need to be equal to the difference between the Net Private Cost and zero. That is, an incentives to reduce Private Cost needs to equal the value Y1-Y2 on Figure 7.

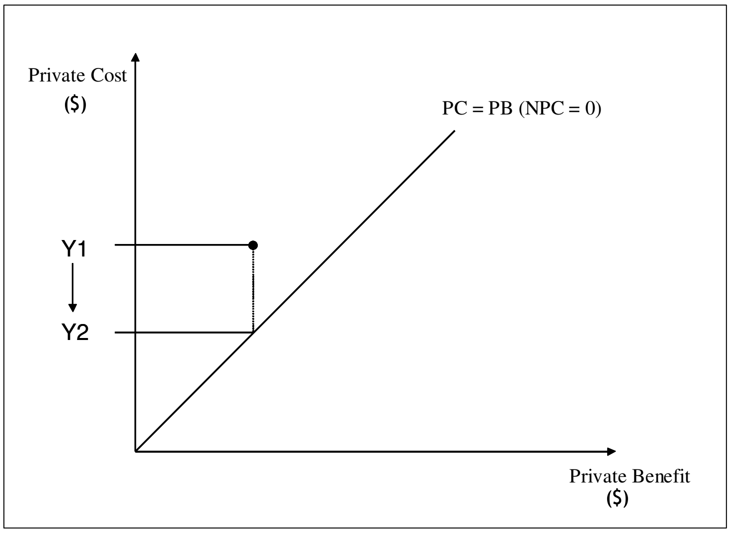

Figure 7: Private Cost versus Private Benefit showing reduction in Private Cost

Another means of reducing Private Cost would be to incorporate the cost of enforcement fines that would be avoided when compliance is improved. The value of this would be based on probability of being caught, probability of a fine and price of the fine. This would be worked into the Net Private Cost (lowering it) as it further promotes compliance.

An alternative to reducing the Private Cost would be to increase the Private Benefit. To ensure compliance, the combination of incentives needs to be equal to the size of the difference between the Net Private Cost and zero. That is, the increased value of the Private Benefit needs to equal the X2-X1 on Figure 8. Some Private Benefits were not incorporated into this research. Including these would cause the number of farms with positive Net Private Cost (if any remain) to reduce. If these additional Private Benefits reduce all Net Private Costs to zero (or below) no further incentives should be required.

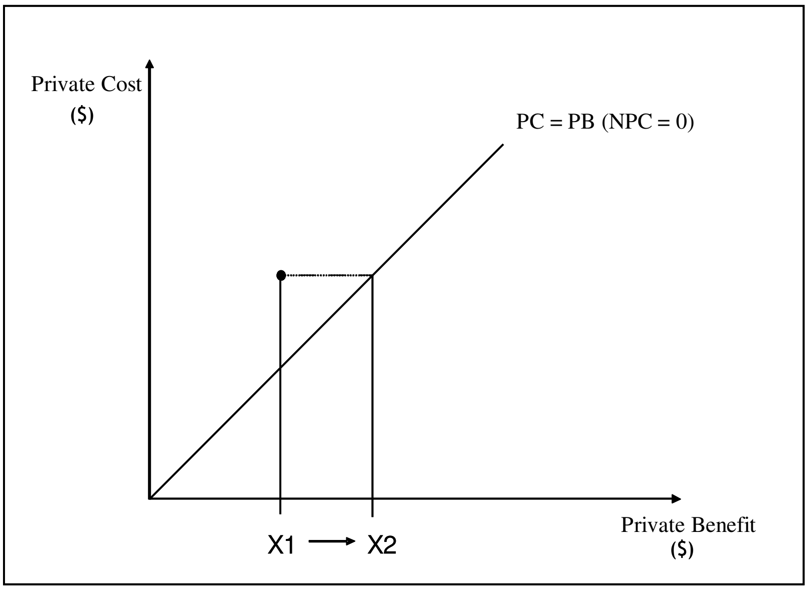

Figure 8: Private Cost versus Private Benefit showing increase in Private Benefit

Projecting the recent trend of increased fertiliser prices may, without intervention, flow-on to increase Private Benefit. An alternative may be to artificially increase (tax) the price of fertiliser. This would increase Private Benefit and could provide a source of funds to subsidise Private Cost. The main problem with this is that all agricultural and horticultural systems use fertiliser but it is primarily the dairy industry that requires the incentive of increased Private Benefit.

4 Conclusion

A historic increase in global economic activity resulting from population growth and increased per-capita income, along with the intensification of farming systems, has been matched by a growing deterioration of the natural environment. The growth and intensification of the dairy industry in New Zealand is not excluded from this trend. The environmental damage this sector causes is well recognised. The four key effects of dairying are damage to water, air, ecosystem biodiversity and human health. The damage to water is, in part, due to poor effluent management. Dairy farming results in a considerable volume of effluent, deposited in the cowshed, which requires disposal. Farm dairy effluent contains high concentrations of contaminants. Effluent disposal needs to be managed so that excessive concentrations of these contaminants do not enter water. The most common means to dispose of effluent is via irrigation. This utilises the natural soil process to breakdown the contaminants and also allows utilisation of the nutrients as fertiliser.

Environment Waikato is the regional authority in the Waikato Region and regulates effluent disposal. About 9% of the farms that irrigate effluent are having the greatest environmental effect and these are classified as 'Significantly Non-Compliant'. In analysing the characteristics of these farms, on average, a total effluent volume of $16m^3$/farm/day will be produced and about half of this will be non-compliant. Non-compliant effluent is the effluent disposed of in a non-compliant manner and is an indicator of Social Benefit. This is because when a farm moves away from a Significantly Non-Compliant status, effluent is withheld from causing adverse environmental effects and a Social Benefit is gained.

The Private Cost to become compliant (Abatement Cost) averages at $10.46/farm/day and the fertiliser content of the non-compliant effluent holds a Private Benefit of, on average, $12.06/farm/day. The average Net Private Cost is, therefore, -$1.61/farm/day. A negative Net Private Cost means that the Private Benefit is greater than the Private Cost and there is an incentive to become compliant.

Of the Significantly Non-Compliant farms, half would make money from becoming compliant. This is because the Private Benefit gained when becoming compliant will outweigh the Private Cost of system or management improvements. On average these farms would gain $0.73/$m^3$ reduction in non-compliant effluent. The average Social Benefit for these farms is $10.8m^3$/day. The Significantly Non-Compliant farms with a positive Net Private Cost will need some other incentive to promote compliance. On average these farms would lose $2.64/$m^3$ reduction in non-compliant effluent. The sum of other incentives would need to counteract this. Fortunately, these farms are primarily those with lower Social Benefit (average $4.5m^3$/day).

Following this research, additional investigation could further define Net Private Cost, bringing in the emotive benefits of compliance (such as social recognition) and the costs of non-compliance fines. Further work could also quantify the Social Benefit into monetary terms. This would result in a true Cost Benefit Analysis being possible. The preliminary step to this, however, may be quantifying the actual environmental effect of the non-compliant effluent.

In summary, approximately half of the Significantly Non-Compliant farms that irrigate effluent to land in the Waikato Region would be better-off by becoming compliant. The other half, although at present may not have an economic incentive to become compliant, are generally those with lower negative effects on the environment.

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